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MISSILE SAFETY AND ARMING CIRCUIT

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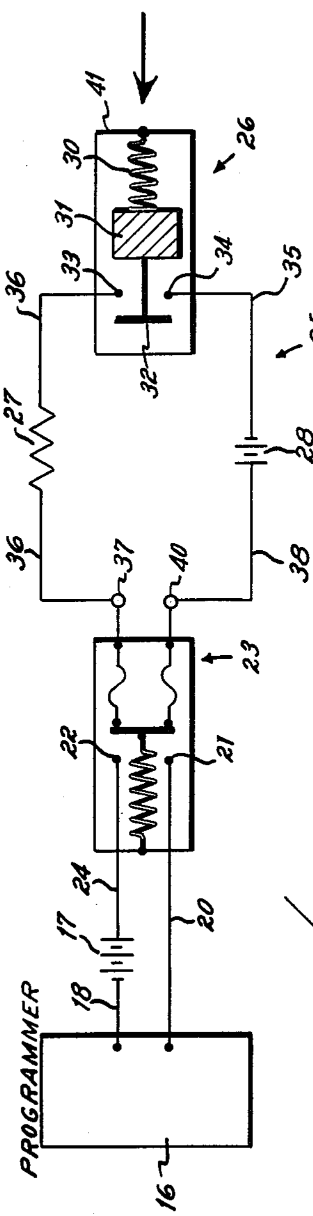

Fig. 2

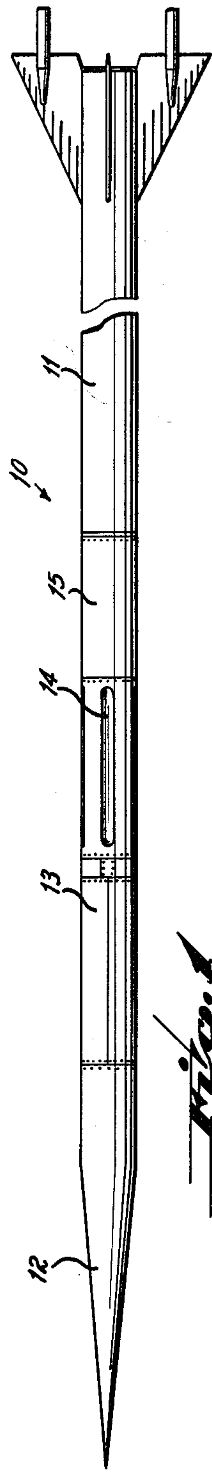

Fig. 1

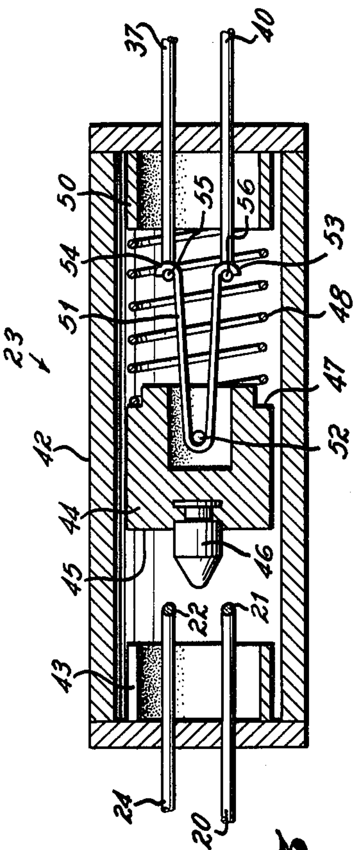

Fig. 3

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MISSILE SAFETY AND ARMING CIRCUIT

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The present invention relates to missile control circuits and is particularly directed to a missile safety and arming circuit for preventing actuation of various missile components until after a missile has been properly launched.

Many missiles in operation today include various explosive or pyrotechnic devices which are utilized at various points in the missile's flight to cause the missile to perform certain predetermined functions. For example, in many missiles explosive means are provided for forcibly separating missile sections following the burn-out of the missile motor or rocket. Many missiles also carry flares which are ignited during the missile flight to facilitate optical or infrared tracking of the missile. It is apparent that any premature actuation of these devices during shipment or pre-launch operations, or in the case of a defective launch can result in injuries in personnel as well as damage to the missile. Thus, the primary function of the missile safety and arming circuit is to prevent actuation of any of these devices until the missile has been properly launched.

The present invention is predicated upon the concept of providing a missile safety and arming circuit comprising the combination of an acceleration responsive electrical switch and a thermal time delay element which cooperate to arm the missile only after the missile has undergone a predetermined acceleration for a preset time. Or viewed somewhat differently, the present arming system obtains a time integral of acceleration and in effect arms the missile only after it has reached a predetermined velocity indicating that the missile has been properly launched.

More particularly, in one preferred form of missile embodying the present invention, control over the various missile components is maintained by a programmer powered by a battery or other power source carried by the missile. The present arming system controls energization of the programmer motor so that the programmer is actuated only after the missile reaches a predetermined velocity.

The present missile safety and arming circuit comprises an acceleration responsive switch having normally open contacts in series connection with a secondary power source, a current limiting, or time delay, resistor, and the fuse wire of a current-sensitive thermal relay. The thermal relay in turn has normally open contacts in series connection with the programmer and its source of power.

In operation, the acceleration switch which is a simple mass spring type of accelerometer is closed as long as the missile is undergoing an acceleration in excess of a predetermined value. When this acceleration switch is closed, current is applied to the fuse wire of the current-sensitive thermal relay. This device functions somewhat like a fuse in that the fuse wire is effective to hold the contacts of the relay open until a predetermined amount of electrical energy is applied to the fuse links causing them to melt. When the fuse links do melt, they release a contact arm which moves under a spring force to close the programmer energization circuit. By way of example, in one embodiment these fuse links require a predetermined current flow for two seconds before the fuse links melt to cause closing of the current-sensitive thermal relay contacts.

Thus, when a missile is fired and reaches a predetermined acceleration, the accelerometer switch closes completing a circuit through the current limiting resistance from the power source to the fuse wire of the thermal relay. If the missile launching is satisfactory and the acceleration continues for two seconds, sufficient current flows through the fuse wire of the thermal relay to cause that relay to close, completing a circuit to the programmer from its power source. Once the thermal relay has been closed, the programmer circuit remains closed no matter what happens to the acceleration switch. If, on the other hand, the acceleration switch should momentarily close and should subsequently reopen, as might be the case for example if the missile were jarred or in the event of a faulty launch, the current flow to the fuse wire of the current-sensitive thermal relay is not sufficient to melt the fuse links so that the programmer is not energized. Then, when the acceleration switch subsequently reopens current flow to the thermal relay stops so that the relay is not closed and the programmer is never energized.

One advantage of the present missile safety and arming circuit is that it is extremely simple and is considerably more reliable than previously suggested arming circuits utilizing mechanical devices such as escapement mechanisms and the like. The only moving parts of the present unit are the mass carried contacts of the acceleration switch and the spring urged contacts of the thermal time delay element. As a result, the operation of the present circuit has a high degree of reliability even under extremely adverse environmental conditions of shock, vibration, temperature and the like.

Another advantage of the present arming system is that despite its high reliability, it is lower in cost than mechanical systems which require relatively complex and intricate mechanical components.

Still another advantage of the present invention is that the thermal time delay relay is a very small component which is approximately the size of a small fuse. This element can be removed from the system during shipment of the missile and can be readily inserted during the final launch operations. Obviously with this element removed from the system it is absolutely impossible to arm the missile irrespective of any shock loads to which the missile might be subjected during transport and set-up for launching.

These and other objects and advantages of the present invention will be more readily apparent from a consideration of the following detailed description of the drawings illustrating a preferred form of the present invention.

In the drawings:

FIGURE 1 is an elevational view of one form of missile embodying the arming and safety circuit of the present invention.

FIGURE 2 is a schematic circuit diagram of an arming and safety circuit of the present invention.

FIGURE 3 is a longitudinal cross-sectional view through one preferred form of current-sensitive thermal relay.

One form of missile **10** with which the present arming and safety circuit can be used is illustrated in FIGURE 1. It is to be understood that missile **10** is merely exemplary and that the present arming and safety circuit can be utilized with many other different types of missiles. As is shown in FIGURE 1, the missile **10** comprises an afterbody section **11** which houses a solid fuel rocket propellant motor. The missile further comprises a nose section **12**, an electronics bay **13**, a parachute receiving bay **14** and a separation section **15**.

This missile is particularly adapted for use as a target missile. In one use of the missile, for example, it is fired to a predetermined altitude for example one hundred thousand feet. The missile is then supported by a parachute for a slow descent while the missile emits electromagnetic radiations suitable for tracking by ground to air or missile-to-missile tracking devices. The missile nose section 12 also house infrared flares which are ignited during flight to provide targets for infrared tracking devices. During the normal flight of such a missile, several explosive devices are actuated in addition to pyrotechnic devices such as the infrared flares carried in nose section 12. Thus, for example, one explosive charge is ignited in separation section 15 to cause afterbody section 11 to be separated from the remaining portions of the missile. A second explosive charge is ignited at the juncture of nose cone 12 and electronics bay 13 to cause the nose cone to be blown away from the remaining portions of the missile. Still other explosive squibs are actuated to perform such functions as severing reefing lines, and the like.

Actuation of the various component elements of the missile is controlled by a programmer 16. The exact details of construction of the programmer 16 constitute no part of the present invention. However, in general, it can be stated that the programmer comprises a motor adapted to be energized from a primary power source, such as battery 17, through a circuit including leads 18 and 20, normally open contacts 21 and 22 of a current-sensitive thermal relay 23 and a lead 24 which interconnects one terminal of battery 17 to contact 22. The motor of programmer 16 drives a plurality of cams which in turn actuate various switches to complete circuits to the various explosive charges and squibs in a predetermined time sequence following actuation of the programmer. Both the programmer 16 and the missile arming circuit indicated generally at 25 are mounted within electronics bay 13.

The missile arming and safety circuit is shown diagrammatically in FIGURE 2. As is there shown, the safety and arming circuit comprises an acceleration responsive switch 26, a resistance 27, current-sensitive thermal relay 23, and a secondary power source, such as batteries 28. More particularly, acceleration switch 26 is a conventional acceleration type of switch of the mass spring type. That is, switch 26 comprises a compression spring 30 which normally retains a mass 31 in a retracted position. Mass 31 carries a contact bridging arm 32 which is normally spaced from two stationary contacts 33 and 34. Contact 34 is connected to one terminal of battery 28 through a lead 35, while contact 33 is joined through lead 36 and resistor 27 to one terminal 37 of relay 23. Another lead 38 interconnects a second terminal 40 of relay 23 to batteries 28. It is to be understood that switch 26 is mounted within missile 10 so that wall 41 of the missile faces forwardly, i.e., faces nose section 12. Thus, when the missile is accelerated, the inertia of mass 31 tends to retard movement of the mass relative to the missile and stationary contacts 33 and 34. Thus, the mass 31 acts against the force of spring 30 and contact arm 32 is brought into bridging relationship with stationary contacts 33 and 34.

Details of construction of one suitable form of current-sensitive thermal relay 23 are shown in FIGURE 3. These relays are commercially available from Thermocal Division of Jamieson Laboratories, Inc. and are sold under the trade name "Pyristor"; other similar relays are available from Networks Electronic Corporation. As is shown diagrammatically in FIGURE 3, the relay 23 includes a housing 42 which hermetically seals the remaining elements of the relay. The relay comprises two rigid stationary contacts 22 and 21 which are carried by a header assembly 43. These contacts are normally spaced from a retractable plunger 44. The plunger includes a forward face 45 from which extends a conductive bullet shaped nose member 46. The shape of this member insures that the plunger enters between contacts 21 and 22 and forms an electrical connection between them. Plunger 44 is provided with an annular rear shoulder 47 which engages one end at a compression spring 48. The opposite end of this spring abuts against a rear header assembly 50.

Plunger 44 is normally held in a retracted position by means of a generally U-shaped fuse wire 51. This fuse wire is looped around a transverse pin 52 extending across a rearwardly opening bore formed in plunger 44. The free ends of fuse wire 51 are looped over as at 53 and 54 for engagement with stationary loop members 55 and 56 carried by rear header assembly 50. When the thermal relay is assembled the fuse wire is effective to hold the plunger 44 in its retracted position with contact face 45 spaced from stationary contacts 21 and 22. This is the position shown in FIGURE 3. However, as soon as fuse wire 51 melts, spring 48 is effective to shift the plunger 44 forwardly to bring the plunger nose 46 into bridging contact with stationary contact terminals 21 and 22. The overall physical size of one suitable thermal relay of this type is approximately an inch in length and a quarter of an inch in diameter. It will, of course, be appreciated that relay housing 42 is thermally insulated to substantially eliminate environmental temperature effects.

In the present missile and arming circuit 25 the components are interrelated so that the size of resistor 27 in relation to the potential of secondary power source 28 and the capacity of fuse wire 51 is such that fuse wire 51 burns out when current flows through it for a predetermined time, for example two seconds, although obviously by changing the resistor size a longer or shorter time could be required.

In operation, thermal relay 23 is placed in the arming circuit only during the final launch preparation. Since the relay contacts 21 and 22 are normally open, the programmer motor is deenergized and circuits cannot be completed to any of the devices controlled by the programmer. After the missile has been launched, the acceleration switch 26 closes its contacts 33 and 34. Thus, a circuit is completed from secondary power source 28 through resistor 27 and leads 38 and 36, to terminals 37 and 40 of the thermal relay 23. Current flows from these terminals through fuse wire 51.

Assuming that the missile has been properly launched and that the acceleration continues for in excess of the preset time, two seconds in this example, the fuse wire is heated to a point where it melts. Thus, plunger 44 is released to move forwardly under the action of spring 48. When the plunger moves forwardly, nose member 46 bridges the stationary contacts 21 and 22 of the relay. A circuit is thus completed through these contacts from power source 17 to the programmer motor. The programmer motor begins to rotate closing the cam operated switches so that the various devices of the missile are actuated in their proper time sequence. It is to be noted that once the fuse member 51 has been melted, to actuate the thermal relay 23, the acceleration switch 26 has no further control over the thermal relay or programmer. Thus, when that switch opens it does not in any way effect operation of the programmer. However, in the event of a faulty launch in which the acceleration is initiated to originally close switch 26, but does not last for a proper time, switch 26 momentarily closes to cause a current to flow through fuse wire 51. However, current does not flow for a sufficient length of time to cause the fuse wire to melt so that the plunger 44 is never released and the missile programmer is never placed in operation.

From the foregoing disclosure of the general principles of the present invention and the above detailed description of a preferred embodiment, those skilled in the art will readily comprehend various modifications of which the present invention is susceptible. Accordingly, I desire to be limited only by the scope of the following claims.

Having described my invention, I claim:

1. A missile safety and arming circuit for a missile including a programmer, said circuit comprising an acceleration responsive switch of the mass-spring type having normally open contacts and including means for closing said contacts when said switch is subjected to a predetermined acceleration and reopening said contacts in the

event said switch is closed in response to said predetermined acceleration and is subsequently subjected to an acceleration less than said predetermined acceleration, an electrical current-sensitive thermal relay having a fuse element, a first source of potential, a resistor means interconnecting said first source of potential, said resistor, said acceleration switch contacts, and said fuse element of said relay in series electrical connection, said relay having a pair of normally open contacts, a power source in series electrical connection with said relay contacts, and means interconnecting said power source and said relay contacts with said programmer, whereby said fuse element melts to energize said programmer only after said acceleration responsive switch is closed for a predetermined time.

2. A missile arming and safety circuit comprising an acceleration responsive switch of the mass-spring type having normally open contacts, and means for closing said contacts when said switch is subjected to a predetermined acceleration and reopening said contacts in the event said switch is closed in response to said predetermined acceleration and is subsequently subjected to an acceleration less than said predetermined acceleration, an electrical current-sensitive thermal relay, said relay comprising a housing, two spaced stationary contacts, a plunger adapted to bridge said contacts to complete an electrical circuit therebetween, spring means urging said plunger toward said bridging position, a fuse wire, means securing said fuse wire to said plunger, and means securing said fuse wire to the housing of said relay, whereby said fuse wire is effective to hold said plunger in a retracted position spaced from said stationary contacts, a first source of potential, means interconnecting said first source of potential, said fuse wire and said contacts of the acceleration switch in series connection, a second power source, means connecting said second power source in series with the normally open contacts of said relay and with a load device.

3. A missile arming and safety circuit comprising an acceleration responsive switch of the mass-spring type having normally open contacts, and means for closing said contacts when said switch is subjected to a predetermined acceleration and reopening said contacts in the event said switch is closed in response to said predetermined acceleration and is subsequently subjected to an acceleration less than said predetermined acceleration, an electrical current-sensitive thermal relay, said relay comprising a housing, two spaced stationary contacts, a plunger adapted to bridge said contacts to complete an electrical circuit therebetween, spring means urging said plunger toward said bridging position, a fuse wire, means securing said fuse wire to said plunger, and means securing said fuse wire to the housing of said relay, whereby said fuse wire is effective to hold said plunger in a retracted position spaced from said stationary contacts, a first source of potential, a resistor, means interconnecting said first source of potential, said resistor, said fuse wire and said contacts of the acceleration switch in series connection, a second power source, means connecting said second power source in series with the normally open contacts of said relay and with a load device.

4. A missile arming and safety circuit for a missile including a programmer, said circuit comprising an acceleration responsive switch of the mass-spring type having normally open contacts, and means for closing said contacts when said switch is subjected to a predetermined acceleration and reopening said contacts in the event said switch is closed in response to said predetermined acceleration and is subsequently subjected to an acceleration less than said predetermined acceleration, an electrical current-sensitive thermal relay, said relay comprising a housing, two spaced stationary contacts, a plunger adapted to bridge said contacts to complete an electrical circuit therebetween, spring means urging said plunger toward said bridging position, a fuse wire, means securing said fuse wire to said plunger, and means securing said fuse wire to the housing of said relay, whereby said fuse wire is effective to hold said plunger in a retracted position spaced from said stationary contacts, a first source of potential, a resistor means interconnecting said first source of potential, said resistor, said fuse wire and said contacts of the acceleration switch in series connection, a second power source, means connecting said second power source in series with the normally open contacts of said relay and said programmer.

5. A missile arming and safety circuit for a missile including a programmer, said circuit comprising an acceleration responsive switch of the mass-spring type having normally open contacts, and means for closing said contacts when said switch is subjected to a predetermined acceleration and reopening said contacts in the event said switch is closed in response to said predetermined acceleration and is subsequently subjected to an acceleration less than said predetermined acceleration, an electrical current-sensitive thermal relay, said relay comprising two spaced stationary contacts, a plunger adapted to bridge said contacts to complete an electrical circuit therebetween, spring means urging said plunger toward said bridging position, a fuse wire, means securing said fuse wire to said plunger, and means securing said fuse wire to the housing of said relay, whereby said fuse wire is effective to hold said plunger in a retracted position spaced from said stationary contacts, a first source of potential, a resistor means interconnecting said first source of potential, said resistor, said fuse wire and said contacts of the acceleration switch in series connection, a second power source, means connecting said second power source in series with the normally open contacts of said relay and said programmer, whereby said fuse element melts to release said plunger and energize said programmer only after said acceleration responsive switch is closed for a predetermined time.

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